

In the claims:

1. (currently amended) A video-based animal behavior analysis system, comprising:  
a computer configured to determine a position and shape of an animal from video  
images and to characterize activity of said animal as one of a set of  
predetermined behaviors based on an analysis of changes in said position and  
said shape over time.
2. (original) The system of claim 1, further comprising:  
a video camera and a video digitization unit coupled to said computer for capturing  
said video images and converting said video images from analog to digital  
format.
3. (original) The system of claim 2, further comprising:  
an animal identification, segregation, and tracking module receiving said video  
images.
4. (original) The system of claim 3, wherein said computer further includes a behavior  
identification module for characterizing activity of said animal, said behavior identification  
module being coupled to said animal identification, segregation, and tracking module.
5. (original) The system of claim 4, wherein said computer further includes a standard  
animal behavior storage module that stores information about known behavior of a

predetermined standard animal for comparing the activity of said animal, said standard animal behavior storage module being coupled to said behavior identification module.

6. (original) The system of claim 1, wherein said animal is a mouse.
7. (original) The system of claim 1, wherein said animal is a rat.
8. (currently amended) A method of determining and characterizing activity of an animal using computer processing of video images, comprising the steps of:
  - detecting an animal in said video images;
  - tracking changes ~~to~~ in position and shape of said animal over a plurality of said video images;
  - ~~identifying and classifying said changes to~~ in position and shape of said animal as postures; and
  - characterizing ~~said~~ activity of said animal as one of a set of predetermined behaviors based on a comparison of a sequence of said postures to pre-trained models or rules of said set of predetermined behaviors ~~such activity~~.
9. (currently amended) The method of claim 8, wherein said step of characterizing ~~said~~ activity includes the steps of:
  - describing a said sequence of said postures as behavior primitives; and
  - aggregating said behavior primitives into actual behavior over a range of images;

10. (currently amended) The method of claim 9, wherein said step of characterizing said activity ~~by describing and aggregating behavior primitives~~ further includes the steps of:

describing a set of conditions and rules required for characterizing said activity

activities; and

matching and testing generated features to see if said condition and rules are

satisfied;

11. (currently amended) ~~The method of claim 8, wherein said detecting an animal includes using a background subtraction method comprising the steps of:~~ A method of determining and characterizing activity of an animal using computer processing of video images, comprising the steps of:

detecting an animal in said video images;

tracking changes to said animal over a plurality of video images;

identifying and classifying said changes to said animal; and

characterizing said activity of said animal based on a comparison to pre-trained

models or rules of such activity, wherein the step of detecting an animal in

said video images includes

applying a lenient threshold on a difference between a current image and a

background so as to determine a broad region of interest;

classifying by intensity values various pixels in said region of interest to

obtain said animal, by selecting only those intensity values that belong

to a the set of model intensity values of said the animal; and

refineing contours of said animal image by smoothing.

12. (currently amended) The method of claim 8 +0, wherein said step of classifying said changes in position and shape of said animal as postures ~~posture determination and description~~ includes using statistical and contour-based shape information.

13. (currently amended) ~~The method of claim 12, wherein said step of identifying and classifying changes to said animal includes using statistical shape information selected from the group consisting of:~~ A method of determining and characterizing activity of an animal using computer processing of video images, comprising the steps of:

detecting an animal in said video images;

tracking changes to said animal over a plurality of video images;

identifying and classifying said changes to said animal; and

characterizing said activity of said animal based on a comparison to pre-trained models or rules of such activity,

wherein said step of characterizing said activity includes the steps of:

describing a sequence of postures as behavior primitives;

aggregating behavior primitives into actual behavior over a range of images;

describing a set of conditions and rules required for characterizing said activities; and

matching and testing generated features to see if said conditions and rules are satisfied;

wherein said posture determination and description includes using statistical and contour-based shape information;

wherein said step of identifying and classifying changes to said animal includes using statistical shape information selected from the group consisting of:

area of said the animal;

centroid position of said ~~the~~ animal;  
bounding box and its aspect ratio of said bounding box of said ~~the~~ animal;  
eccentricity of said ~~the~~ animal; and  
directional orientation of said ~~the~~ animal relative to an axis as generated with a  
Principal Component Analysis.

14. (currently amended) The method of claim 12, wherein said step of ~~identifying and~~  
classifying said changes in position and shape of said animal as postures ~~changes to said~~  
~~animal~~ uses contour-based shape information selected from the group consisting of curvature  
measures, thickness measures, relative orientation measures, length measures, and corner  
points.

15. (currently amended) The method of claim 12, wherein said step of ~~identifying and~~  
classifying said changes in position and shape of said animal as postures ~~changes to said~~  
~~animal~~ includes identifying a set of model postures and ~~their~~ description information for said  
set of model postures, said set of model postures including a horizontal side view posture, a  
vertical posture, a cuddled posture, a horizontal front/back view posture, a partially reared  
posture, a stretched posture, a hang vertical posture, a hang cuddled posture, an eating  
posture, and a drinking posture.

16. (currently amended) The method of claim 12 ~~15~~, wherein said step of ~~identifying and~~  
classifying said changes in position and shape of said animal as postures ~~changes to said~~  
~~animal~~ includes classifying the statistical and contour-based shape information from a current  
image to assign a best-matched posture.

17. (currently amended) The method of claim 9-10, wherein the said step of describing said sequence of said postures as said behavior primitives includes ~~the step of~~ identifying patterns of postures over a sequence of images.

18. (currently amended) ~~The method of claim 17,~~ A method of determining and characterizing activity of an animal using computer processing of video images, comprising the steps of:

detecting an animal in said video images;

tracking changes to said animal over a plurality of video images;

identifying and classifying said changes to said animal; and

characterizing said activity of said animal based on a comparison to pre-trained models or rules of such activity,

wherein said step of characterizing said activity includes the steps of:

describing a sequence of postures as behavior primitives;

aggregating behavior primitives into actual behavior over a range of images;

describing a set of conditions and rules required for characterizing said activities; and

matching and testing generated features to see if said conditions and rules are satisfied;

wherein the said step of describing said behavior primitives includes the step of identifying patterns of postures over a sequence of images; and

wherein said step of describing said behavior primitives step further includes the step of analyzing temporal information selected from the group consisting of direction and magnitude of movement of the centroid, increase and decrease of the eccentricity, increase

and decrease of the area, increase and decrease of the aspect ratio of ~~a~~ the bounding box, and change in contour information.

19. (currently amended) The method of claim 10, wherein the said step of ~~determining actual behavior by~~ aggregating said behavior primitives includes ~~the step of~~ analyzing temporal ordering of the said behavior primitives, such as using information about a transition from a previous behavior primitive to a next behavior primitive, and applying all applicable conditions and rules.

20. (currently amended) The method of claim 19, wherein said analyzing temporal ordering of said behavior primitives ~~temporal analysis~~ is a time-series analysis such as Hidden Markov Model (HMM).

21. (currently amended) The method of claim ~~8~~ 19, wherein ~~the said step of determining actual behavior includes identifying actual behavior selected from a group~~ set of predetermined behaviors corresponds to a set of pre-trained behavior models.

22. (currently amended) The method of claim ~~8~~ 21, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes rearing up to a fully reared up or partially reared up position, ~~and said rearing behavior which~~ is determined by a the sequence of postures starting from cuddled, horizontal side-view, or horizontal front/back view postures to ending in a vertical or partially reared posture;

23. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes coming down from a  
reared up or partially reared up position, ~~and said come down behavior~~ which is determined  
by ~~a~~ the sequence of postures starting from vertical or partially reared postures to ending in a  
cuddled, horizontal side view or horizontal front/back view posture;

24. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes eating, ~~and said~~  
~~eating behavior~~ which is determined by a sequence of eating postures where the mouth of  
~~said~~ the animal is in touch with a food container;

25. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes drinking, ~~and said~~  
~~drinking behavior~~ which is determined by a sequence of drinking postures where the mouth  
of ~~said~~ the animal is in touch with a water spout;

26. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes digging, ~~and said~~  
~~digging behavior~~ which is determined by the aft movement of bedding by ~~said~~ the animal  
with its fore and hind limbs;

27. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes foraging, ~~and said~~



~~foraging behavior~~ which is determined by the movement of bedding using the mouth and forelimbs;

28. (currently amended) The method of claim 8 ~~21~~, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes jumping, and said jumping behavior which is determined by a single up and down movement of said the animal;

29. (currently amended) The method of claim 8 ~~21~~, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes jumping repetitively and said repetitive jumping behavior , which is determined by several continuous up and down movement of said the animal;

30. (currently amended) The method of claim 8 ~~21~~, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes sniffing, and said sniffing behavior which is determined by random brisk movement of the head while the rest of the body remains stationary;

31. (currently amended) The method of claim 8 ~~21~~, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes hanging from the top of the cage, and said hanging behavior which is determined by a sequence of postures starting from vertical posture to ending in a hang vertical or hang cuddled posture;

32. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes landing after  
hanging, and said landing behavior which is determined by a sequence of postures starting  
from a hang vertical or hang cuddled posture to ending in a vertical posture;

33. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes sleeping, and said  
sleeping behavior which is determined by the absence of major movements of the contour of  
said the animal for a prolonged period of time;

34. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes twitching during  
sleep, and said twitch behavior which is determined by the detection of a brief period of  
substantial movement and then resumption of sleep activity;

35. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes awakening from  
sleep, and said awaken behavior which is determined by a prolonged movement of said the  
animal after sleep has set in;

36. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~  
~~models includes the behavior of~~ set of predetermined behaviors includes grooming, and said  
grooming behavior which is determined by brisk movement of limbs and mouth in a cyclical  
and periodic pattern;

37. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~ ~~models includes the behavior of~~ set of predetermined behaviors includes pausing briefly, and said ~~pause behavior~~ which is determined by brief absence of movement of said the animal;

38. (currently amended) The method of claim 8 21, wherein said group of behavior models includes the behavior of urinating, and said urinate behavior is determined by the detection of the tail being raised up and the animal remaining stationary briefly;

39. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~ ~~models includes the behavior of~~ set of predetermined behaviors includes turning, and said ~~turn behavior~~ which is determined by a sequence of postures starting from horizontal side view or cuddled posture to ending in a horizontal front/back view posture, and vice versa;

40. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~ ~~models includes the behavior of~~ set of predetermined behaviors includes circling, and said ~~circling behavior~~ which is determined by a ~~3~~ three or more successive turns;

41. (currently amended) The method of claim 8 21, wherein said ~~group of behavior~~ ~~models includes the behavior of~~ set of predetermined behaviors includes walking or running, and said ~~walking or running behavior~~ which is determined by the continuous sideways movement of the centroid of said the animal;

42. (currently amended) The method of claim 8 21, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes body stretching its body vertically or horizontally, ~~and said stretch behavior~~ which is determined by a concave shape of said ~~the~~ animal's back;

43. (currently amended) The method of claim 8 21, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes chewing, ~~and said chewing behavior~~ which is determined by the movement of the mouth while the mouth is not in touch with a food container;

44. (currently amended) The method of claim 8 21, wherein said ~~group of behavior models includes the behavior of~~ set of predetermined behaviors includes remaining stationary, ~~and said stationary behavior~~ which is determined by said ~~the~~ animal remaining in the same place and not performing any of the other predetermined behaviors;

45. (currently amended) The method of claim 8 21, wherein ~~if~~ said set of predetermined behaviors includes unknown behavior, which is the activity that cannot be characterized by any of a set of ~~the~~ behavior models, ~~the behavior is deemed unknown~~;

46. (currently amended) The method of claim 8, wherein said steps are ~~also~~ performed in night conditions by using red light to simulate such night conditions, or by using infra-red cameras to capture ~~the~~ images with no light;

47. (currently amended) The method of claim 8, wherein said steps are ~~also~~ performed with a plurality of cages or arenas, each of which contains a single animal;
48. (currently amended) The method of claim 8, wherein said step of detecting an animal includes ~~the step of detecting body parts of~~ said ~~the~~ animal;
49. (currently amended) The method of claim 48, wherein said body parts include the head;
50. (currently amended) The method of claim 48, wherein said body parts include the tail;
51. (currently amended) The method of claim 48, wherein said body parts include the ear;
52. (currently amended) The method of claim 48, wherein said body parts include the upper and lower back;
53. (currently amended) The method of claim 48, wherein said body parts include the abdomen;
54. (currently amended) The method of claim 48, wherein said body parts include the hind-limbs;

55. (currently amended) The method of claim 48, wherein said body parts include the forelimbs;